

The Vascular Surgery Operating Room

Development of an up-to-date operating room that will meet the demands of the vascular surgery patient and team.

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Physicians are faced with a number of challenges in the current medical environment. These challenges include significant changes in the demographics of the patients we treat, rapid advances in technology, increased costs to provide these services, and the need for a working environment that can allow for the adaptation of this process. The vascular surgeon specialist has not been immune to these challenges and may be one of the medical specialists most acutely affected by them.

The population is experiencing a significant increase in the number of people over the age of 60. Concomitant with this increase in the aging population is an increase in the number of patients with medical problems, including vascular disease. The prevalence of vascular disease increases with age, and estimates suggest the prevalence exceeds 65% in both men and women over the age of 65.¹

In addition to an increasing patient population, there had been a rapid evolution in the treatment of vascular disease, mostly due to the advancements in endovascular technologies. Stent-graft treatment of aortic aneurysms and percutaneous treatment of peripheral occlusive disease are surpassing conventional vascular surgery. In fact, from 2000 to 2005, the number of endovascular procedures for peripheral vascular disease, aortic aneurysmal disease, and carotid artery occlusive disease is more

than twice that of conventional open procedures.¹ This evolution in the treatment of vascular disease stresses our current operating room environment—it was not designed for modern day vascular surgery. In order to continue to provide quality vascular care, the vascular surgeon must develop an operating room that more readily integrates the latest imaging and procedural technology. After all, it is in the operating room that the definitive care of our patients usually takes place, and it is where a significant amount of our time is spent. In addition, the operating room design must allow for the flexibility to evolve as our specialty continues to change. The need to address the quality, safety, technical, and personnel issues in the operating room while optimizing perioperative processes has become critical.

Vascular surgeons should consider several key components when updating their operating rooms to meet the demands of the rapidly evolving practice. Although challenging, this redesign can be successfully accomplished,



Figure 1. The control room (A) offers a site for postprocessing of digitally obtained images. In this instance, it is adjacent to the endovascular operating room (B), and through the windows there is direct visualization of the procedures. The computer system is linked to the hospital's digital image storage system, and images are subsequently downloaded into the storage sites and are easily reviewed at any radiologic workstation throughout the healthcare system.



Figure 2. The substerile corridor is outside the three operating rooms, which are on the right side of each frame. An image before renovation (A), a depiction of the anticipated design (B), and a wide-angle lens view of the same area after construction (C). Execution of the plan as depicted was on target.

and we will review an example of how such an upgrade has been successfully accomplished by our colleagues in orthopedic surgery.

KEY ELEMENTS OF A VASCULAR OPERATING ROOM

Before the operating room can be updated, certain characteristics, such as the types of cases performed in each room, must be identified. Much of this analysis will depend on the local vascular market and practices. Will the surgeon have the luxury of having both an environment strictly for the performance of percutaneous procedures, as well as one strictly devoted to conventional, open vascular surgery? In all likelihood, most surgeons will have one environment in which to undertake both aspects of their practices. This single environment will enable, however, an easier transition when performing complex hybrid procedures that will necessitate the combination of both endovascular and open techniques. However, many aspects of current operating room designs render them inflexible for the performance of complex endovascular procedures. Some key elements that must be taken into consideration when developing an updated operating room are highlighted.

Space

One of the most necessary aspects that is often the least considered is the need for adequate and proximate storage space for a stock of implantable materials and disposable items that is easily and quickly retrievable. These will include an inventory system to track and replace many readily used items, such as catheters, sheaths, wires, percutaneous transluminal angioplasty balloons, and stents. In addition to space for storage, there is a need for increased working space within the operating room. Meeting this increasing need for space

may not necessarily be obtained by expanding the total square footage of the room but by eliminating unnecessary elements that obstruct the working space. Although a conventional operating room requires some basics, such as an instrument table, operating table, and anesthesia area, there is increased need in an endovascular suite to accommodate a movable table, the imaging equipment, and additional technologic supplements, such as intravascular ultrasound, mechanical thrombolytic machinery, and accessory tables to hold the percutaneous equipment. Furthermore, added space is necessary to allow for flexibility when approaching patients with percutaneous access. It may be necessary to access a patient via either the brachial or femoral artery, and the room must be convertible enough to accommodate this capability. Steric constraints can be modeled using computer-aided design applications to help the entire surgical team understand and optimize procedural flow.

Imaging Acquisition and Storage

One of the biggest decisions to make when converting a conventional operating room to an endovascular one is the addition of imaging equipment for data acquisition. There are many benefits and detriments to the various imaging modalities available, and it is beyond the scope of this article to discuss all of them. Briefly, the first choice is between fixed and portable equipment. Certainly, the portable equipment offers the most flexibility, and with the current available technology, the image quality is quite good. It may, however, offer inferior imaging capabilities if more complex endovascular procedures are necessary. Fixed imaging equipment offers the opportunity to upgrade to the latest flat panel detector technology and provides significantly superior imaging quality. As more sophisticated endovascular procedures are attempted, we prefer fixed imaging equipment



Figure 3. The operating room of the future demonstrating the circulating nurse at the documentation and control station (A). All computer units are housed in the cabinets, and the monitors and keyboards are on the surface, leaving enough room to handle the paperwork. The knee radiographs can be seen on the far left on the view boxes. The center panel (B) demonstrates the ability of the scrub nurse to see in the field using a boom-mounted monitor. On the far wall, the cabinets contain the nursing supplies typically needed during a case. The panel on the right (C) focuses on the anesthesia supply wall. Note the monitor at the patient's level per his request to observe the knee replacement from skin to skin. This monitor is also used by the anesthesiologist to see in the field without having to lean over the patient or the drapes.

because it provides improved imaging quality with less radiation exposure. On the downside, both ceiling- and floor-mounted units provide limited flexibility with regard to room design and layout, given the nature of their construction and require floor and ceiling support that may not be readily available in existing structures.

Data acquisition upgrades are not limited to the addition of a C-arm. In addition, surgeons should consider the construction of a control room (Figure 1). This is a separate, lead-lined room adjacent to the operating room that has a link to the C-arm data acquisition. The control room houses the computer equipment necessary for postprocessing of the images and provides for an ample workspace to accomplish this. Once the images are obtained, the next key component in establishing an updated endovascular operating room is the need for data storage. A secure system is necessary for cataloging and storing either the digital images electronically, or the printed images in a film library. Later, access to these images is crucial for treating vascular disease. Many systems can be incorporated into pre-existing digital systems available at individual hospitals.

Data Visualization

Because imaging technology has evolved, the use of printed film has significantly decreased. In addition, with the development of sophisticated imaging techniques combined with complex endovascular reconstructions, there is a greater reliance on the ability to view reconstructed images, such as three-dimensional computed tomography (CT). Although these images are often viewed preoperatively, the ability to view and manipu-

late them intraoperatively can be tremendously helpful during endovascular procedures. Given this, there is less need for conventional view boxes in the operating room and increased need for computer systems with wall- or boom-mounted monitors. In addition, the electronic three-dimensional reconstruction of CT scans is often very helpful intraoperatively. Touch screen technology on these monitors can facilitate the interface between the surgeon and the imaging modality within a sterile environment.

PLANNING FOR THE FUTURE

One of the key elements in designing the updated operating room is to ensure that there is flexibility in the plans that will allow for later upgrades. Technology often evolves faster than our ability to rebuild, and our ability to upgrade is integral. Accomplishing this extraordinary feat requires communication among the surgeons, administrators, contractors, and architects.

Similar demographic, technical, and procedural workflow issues are challenging our colleagues in orthopedic surgery. The aging population has resulted in more patients requiring joint replacement, the technology continues to evolve including the use of surgical navigation, and the need to increase volume of procedures is of significant interest. The consumer demand for improved mobility and function is also increasing. Optimizing perioperative and intraoperative processes to permit increases in volume will accommodate the rising demand for those services. The "Orthopedic Operating Room of the Future" program was developed to provide dedicated state-of-the-art orthopedic oper-

ating rooms that could focus on knee, hip, and shoulder arthroplasty while accommodating other orthopedic procedures. Once the operating rooms were developed, the goal was to continue the Lean Six Sigma effort to increase the safety and efficacy of orthopedic procedures. Simply put, the goal was one more case per day per room.

At first glance, the operating rooms in most hospitals are only in use for at most 10 hours per day—a 42% utilization at best during a 24-hour period. In that period, the case types, duration, surgeon variability, and personnel needs were evaluated. Design engineers, architects, and process engineers observed and communicated with the people who spend the most time in the room: the nurses, the surgical technicians, the orthopedic technicians, the surgeons, the anesthesiologists, environmental services personnel, and residents and fellows. In short, every user was questioned, and their opinions were solicited to maximize the design criteria.

The results of this extensive data-gathering phase were presented to all concerned parties in an open house in which the new design for the operating room was presented (Figure 2). As with vascular surgery, the use of equipment to control and power instruments and the presentation of images were deemed important. Lighting of the operating field, in-room supply capability, and equipment bays were also discussed at length. By focusing on each surgeon and each surgery type, the design team developed an operating room that was able to accommodate multiple users and uses. The next step was to finalize the plans and provide everyone concerned with a construction schedule that was designed to minimize impact on productivity and patient care. Three operating rooms and the surrounding support areas were included in this phase of the project.

Key features of the design were ceiling-mounted equipment booms and lights, concentration of nursing supplies on one wall, anesthesia supplies on another wall, and all controls for lighting, cameras, computers, and systems on a third wall with x-ray view boxes. Given the upcoming implementation of picture archiving and communication systems into the operating room, the view box area was designed to eventually be replaced with a video wall. The control station was designed to permit working space for the circulating nurses as well as easily reached phones, switches, and room controls. Although the booms required an extensive steel superstructure, the engineers determined that the existing ceiling could support the design plans. Having all of the equipment, such as the power for burrs, arthroscopic instruments, fluid pumps, and tourniquets, on one equipment boom facilitates use and most importantly provides a home for the equip-

ment while lifting everything off the floor. This last point was most important to the staff that was responsible for ensuring the cleanliness of the operating room because floor-based equipment and their cords needed moved between each case. The lights were fitted with cameras, permitting scrub staff, circulating nurses, anesthesia team, and even patients under regional anesthesia the ability to see without risking contamination or moving away from the primary station. The in-field monitors also permit the circulating nurses to project electronic medical records, pathology reports, images, or other important information so that the surgical team can view the information without leaving the operative field (Figure 3).

The schedule called for closing one operating room at a time for approximately 63 business days each while the renovation was underway. Although this called for a decrease in the number of cases during that time, the operating room team performed in an exemplary manner and, thanks to their hard work and dedication, the number of cases during construction was significantly increased as compared to the same period for the previous year.

CONCLUSION

The operating room of the future for any hospital and its surgical team requires the initial focus on problem definition and scope. Being realistic in setting expectations is as important as is quantifying each problem that the staff encounters in the current environment. Documentation of even the smallest detail and sharing of the information is also critical to a successful project. Above all, the design and development team were very sensitive to those whose shoes walked the rooms every day. Now that the three rooms and adjoining areas are futuristic, the volumes as well as complexity and variety of procedures have continued to increase along with patient satisfaction. ■

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